Specification Shows Proposed Corrections

U.S. PATENT
Docket No. 45074.32

DETERMINATION OF OIL AND WATER COMPOSITIONS OF OIL/WATER EMULSIONS USING LOW FIELD NMR RELAXOMETRY

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PRIORITY CLAIM

This application claims the priority benefit of Canadian Patent Application No. 2,342,007 filed on March 26, 2001 as file no. 45074.9 and entitled Determination of Oil and Water Compositions of Oil/Water Emulsions Using Low Field NMR Relaxometry.

FIELD OF THE INVENTION

The present invention relates to methods and apparatuses for determining oil and water compositions of heavy oil/water emulsions using low field NMR relaxometry.

BACKGROUND OF THE INVENTION

Low field Nuclear Magnetic Resonance (NMR) relaxometry techniques have been developed in the laboratory to enhance and support comparable NMR logging tools that are currently used downhole. Low field NMR relaxometry involves relaxometers operating at about 2 MHz or less. Low field NMR relaxometry has shown that discrimination of water and oil saturation in core and ore can be easily determined. In such cases the NMR can detect the total water weight fraction and the total oil weight fraction, the viscosity of the oil, the amount of bound or mobile water and the amount of mobile or bound oil.

One particular problem is the determination of oil and water content of specific hydrocarbon streams. Of particular interest are the streams that contain heavy oil in

emulsified fluids (water-in-oil or oil-in-water emulsions) which are currently very common in thermal production operations and are very difficult to handle. Test separators are currently used as the standard way of measuring the flow of thermally produced wells such as cyclic steam stimulation (CSS), steam assisted gravity drainage (SAGD) and steam flooding wells. The test separators are inherently incapable of measuring emulsified flow. Other probe-type devices suffer from inaccuracies related to the presence of solids or gas, salinity, temperature, velocity, emulsion type, and range of cut.

Therefore, there is a need in the art for methods and apparatuses to discriminate quickly, accurately and precisely the amount of heavy oil or bitumen and water in an emulsified fluid stream.

SUMMARY OF THE INVENTION

The present invention is based on the discovery that the NMR spectra of an emulsified mixture of heavy oil or bitumen and water consists of two sets of T_2 relaxation peaks. At the specific temperature of 30°C, the water peaks are typically in the range of 10 to 3000 milliseconds while the oil/bitumen peaks are typically in the range of 0.2 to 10.0 milliseconds. The ranges of these peaks may be affected by the degree of emulsification or separation of the hydrocarbon and aqueous phases, the temperature and the presence of additives. The spectrum of the oil/bitumen component diminishes at lower temperatures and may not be completely recovered at relatively lower temperatures.

Therefore, in one aspect of the invention, there is provided a method of determining the oil fraction of a fluid emulsion comprising heavy oil/bitumen and water by direct measurement comprising the steps of:

(a) providing a low field NMR relaxometer;

(b) measuring and recording the T_2 relaxation spectrum of the emulsion at a temperature allowing recovery of the T_2 spectrum of the heavy oil/bitumen, substantially separate from a T_2 water peak;

(c) determining a distinguishing T_2 cutoff value;

(d) measuring the total amplitude (A_{oil}) of the spectrum at T_2 times less than and equal to the T_2 cutoff value;

(e) converting A_{oil} to a weight value by dividing A_{oil} by the amplitude index of an oil standard (AI_{oil}).of known weight; and

(f) using the weight value to determine the oil fraction of the fluid emulsion.

In another aspect, the invention comprises a method of determining the water fraction of a fluid emulsion comprising heavy oil/bitumen and water by direct measurement comprising the steps of:

(a) providing a low field NMR relaxometer;

(b) measuring and recording the T_2 relaxation spectrum of the emulsion;

(c) determining a distinguishing T_2 cutoff value;

(d) measuring the total amplitude (A_w) of the spectrum at T_2 times greater than the T_2 cutoff value;

(e) converting A_w to a weight value by dividing A_w by the amplitude index of a water standard (AI_w).of known weight; and

(f) (f) using the weight value to determine the water fraction.

In another aspect, the invention comprises an apparatus for determining by direct measurement the oil fraction of a flowing fluid emulsion comprising heavy oil/bitumen and water comprising:

(a) a low field NMR relaxometer having a NMR magnet positioned in proximity to a channel through which the emulsion flows, said relaxometer for measuring the T_2 spectrum of a the sample at a temperature allowing recovery of the T_2 spectrum of the heavy oil/bitumen, substantially separate from a T_2 water peak;

(b) means for identifying a distinguishing T_2 cutoff value;

(c) means connected to the relaxometer for measuring total T_2 amplitude below ~~a~~ the T_2 cutoff value, wherein a substantial portion of the spectrum attributable to the oil is at T_2 values less than or equal to the T_2 cutoff value;

(d) means for converting the total T_2 amplitude value to a weight value; and

(e) means for determining the weight value to determine the oil fraction of the fluid emulsion.

In yet another aspect, the invention comprises an apparatus for determining by direct measurement the oil fraction of a fluid emulsion comprising heavy oil/bitumen and water comprising:

(~~d~~) means for obtaining a sample of the emulsion;

(~~b~~) a low field NMR relaxometer for measuring the T_2 spectrum of the sample at a temperature allowing recovery of the T_2

spectrum of the heavy oil/bitumen, substantially separate from a T_2 water peak;

(c) means for identifying a distinguishing T_2 cutoff value;

(d) means connected to the NMR relaxometer for measuring total T_2 amplitude below a the T_2 cutoff value, wherein a substantial portion of the spectrum attributable to the oil is at T_2 values less than or equal to the T_2 cutoff value;

(e) means for converting the total T_2 amplitude value to a weight value; and

(f) means for determining the weight value to determine the oil fraction of the fluid emulsion.

In another aspect, the invention comprises a method of determining by direct measurement the oil fraction and water fraction of a fluid emulsion comprising heavy oil/bitumen and water comprising the steps of:

(a) providing a low field NMR relaxometer;

(b) measuring and recording the T_2 relaxation spectrum of the emulsion at a temperature allowing recovery of the T_2 spectrum of the heavy oil/bitumen substantially separate from a T_2 water peak;

(c) determining a distinguishing T_2 cutoff value;

(d) measuring the total amplitude (A_{oil}) f the spectrum at T_2 times less than and equal to the T_2 cutoff value;

(e) converting A_{oil} to a weight value by dividing A_{oil} by the amplitude index of an oil standard (AI_{oil}) of known weight;

(f) measuring the total amplitude (A_w) of the spectrum at T_2 times greater than the T_2 cutoff value;

(g) converting A_w to a weight value by dividing A_w by the amplitude index of a water standard (AI_w).of known weight; and

(h) using the oil weight value and the water weight value to determine the oil fraction and water fraction respectively.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described by way of exemplary embodiments with reference to the accompanying drawings. In the drawings:

Figure 1 shows a typical NMR T_2 spectra from two different emulsions.

Figure 2 shows the comparison of NMR predicted water content vs. Dean-Stark measured water content for three different batches of samples form reservoir 1.

Figure 3 shows the same results as Figure 2 but are grouped and the trend-line is plotted.

Figure 4 shows the comparison of the NMR predicted data and the Dean-Stark measurement data for three samples of reservoir 2.

Figure 5 shows a comparison of the results of reservoir 1 and reservoir 2.

Figure 6 shows the same results as Figure but are grouped and the common trend-line is plotted.

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This is the first page of 7

FROM	Edward (Ted) Yoo		
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This facsimile was successfully transmitted at:

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Further to our telephone discussions this morning, please find enclosed proposed amendments to the specification. All additions to the spec are in 14 pt font and underlined.

Edward Yoo, 41435